



PATENT ABSTRACTS OF JAPAN

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(54) SEMICONDUCTOR LASER AND ITS MANUFACTURE

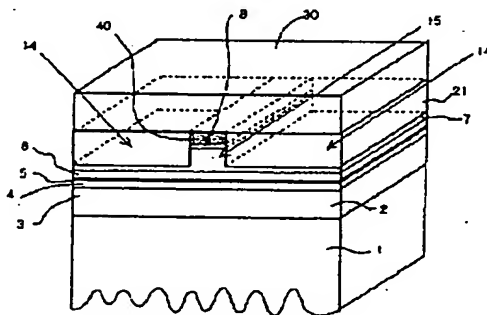
(57) Abstract:

PROBLEM TO BE SOLVED: To prevent an element from being damaged due to contact of a ridge with a heat sink by laminating a cladding layer and a contact layer on a laser structure in this order, forming ridge stripes on the top of flat areas on both sides, and forming a buried layer in the stripes out of polycrystalline insulating material.

SOLUTION: A ridge-type semiconductor laser consists of a structural layer comprising a cladding layer 3 of n-type AlGaIn, a guide layer 4, an active layer 5, a guide layer 6, and a cladding layer 7 of p-type AlGaIn. This structural layer is formed by forming a current path layer 2 of n-type GaN on a sapphire substrate 1, forming flat areas 14 on both sides of the cladding layer 7 and ridge stripes 15, and forming a contact layer of p-type GaN and electrodes 40 and 30 on the flat top of the stripes 15. A buried layer 21 is formed in the stripes 15 on the both-side flat areas 14 using a polycrystalline insulating material of AlN having a lower refractive

index than that of the laser structural layer. Since the buried layer 21 is polycrystalline, cracking due to a difference in lattice constant does not occur between it and the AlGaIn portions.

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CLAIMS

[Claim]

[Claim 1] The process which is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on the laser structure layer on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The embedding stratification process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, The semiconductor laser manufacture technique characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.

[Claim 2] The semiconductor laser manufacture technique of the claim 1 publication characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})\text{-yInyN}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$).

[Claim 3] The aforementioned embedding stratification process is the claim 1 characterized by including a sputter process, or the semiconductor laser manufacture technique given in two.

[Claim 4] Semiconductor laser characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ***** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.

[Claim 5] Semiconductor laser of the claim 4 publication characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})\text{-yInyN}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$).

[Claim 6] The polycrystal insulating material which makes the above AlN a principal component is semiconductor laser the claim 4 characterized by being AlN, or given in five.

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DETAILED DESCRIPTION

[Detailed description]

[0001]

[The technical field to which invention belongs] this invention relates to semiconductor laser and its manufacture technique.

[0002]

[Prior art] Semiconductor laser is known as an element which it is used for the light source of optical-pickup equipment of in read-out / optical information record regenerative apparatus to write in for a signal from an optical disk, and also may be applied to optical transmission systems, such as optical CATV, the pump light source of high-density information record SHG short wavelength laser or small solid state laser, an optical instrumentation field, etc. In order to operate by the small current and to perform a longitudinal direction single-mode oscillation, it is necessary to confine the electron, the electron hole, and oscillation light in a semiconductor in a parvus field. In the pn junction perpendicular direction, it has shut up by double hetero structure etc. Although there is gain **** structure as technique of restricting the photogenesis field of laser, about orientation parallel to a junction, in order that a front may generally be distorted and astigmatism may come out of this, for the intended use of the light source for disk read, the semiconductor laser of refractive-index **** structure is used. Refractive-index **** structure is the structure where carry out forming not only a junction perpendicular direction but a ridge stripe etc., and a junction parallel direction also faces across a photogenesis field at the charge of a clad plate with a low refractive index.

[0003] Since the effective refractive index to the light which spreads the guide layer of the ridge lower part will become large a little from the other fraction if a part of clad layers other than the fraction of a current injection field are removed by etching etc. and a ridge stripe is formed, light is shut up by the ridge lower fraction. An electrode is prepared in the ridge upper part, and a current is poured in and it is made to oscillate between an electrode and a substrate in ridge type semiconductor laser.

[0004]

[Object of the Invention] On the other hand, occurrence of heat becomes a problem when using semiconductor laser by continuous oscillation. Then, in order to improve thermolysis, mounting of the so-called junction down the electrode of the ridge upper part is contacted [the down] to a heat sink is performed. Since the width of face of the projected ridge fraction is several [only] micrometers when it is going to perform

this installation technique, there is a problem by which an element will be destroyed in this ** with a heat sink.

[0005] Then, the need of carrying out the flattening of the side from which the ridge stripe fraction of laser is made arises. It embeds to the almost same height as a ridge stripe fraction, and considers forming and carrying out the flattening of the layer.

However, in SiO₂, along with the side attachment wall of the ridge section, it had to form thinly, the flattening was difficult, and selection of an embedding material was difficult.

[0006] Then, it aims at offering the ridge type semiconductor laser which has a ridge stripe on the laser structure layer which can be equal to junction down mounting, and its manufacture technique in this invention.

[0007]

[The means for solving a technical problem] The process which this invention is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe on a laser structure layer, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, It is characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.

[0008] In the manufacture technique of the semiconductor laser of this invention, it is characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})\text{-yIn}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$). In the manufacture technique of the semiconductor laser of this invention, it is characterized by the aforementioned embedding stratification process including a spatter process.

[0009] The semiconductor laser of this invention is characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ***** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.

[0010]

[Gestalt of implementation of invention] Hereafter, the example of this invention is explained, referring to a drawing. First, the ridge stripe embedding technique in the n type semiconductor layer in the ridge type semiconductor laser which has a ridge stripe is explained. Ridge type semiconductor laser is shown in drawing 1. This ridge type semiconductor laser has the laser structure which consists of the clad layer 3 of n

type AlGaIn, the guide layer 4 of n type GaN, the barrier layer 5 of InGaIn, a guide layer 6 of p type GaN, and a clad layer 7 of p type AlGaIn. A laser structure layer is a multilayer which makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_y\text{N}$ ($0 \leq x \leq 1$; $0 \leq y \leq 1$). In order to form this laser structure layer on the silicon on sapphire 1 in which the current path layer 2 of n type GaN was formed and to shut up light, the ridge stripe 15 for which the clad layer 7 of p type AlGaIn projects from the both-sides flat part 14 into which it was etched, and these is formed on the laser structure layer. Moreover, the contact layer 8 of p type GaN, and the stripe-like 2nd electrode 40 are formed in the flat top section of the ridge stripe 15, and the p lateral electrode 30 is further formed on it.

[0011] This ridge type semiconductor laser has the embedding layer 21 which sandwiches the ridge stripe 15 which deposited the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the both-sides flat part 14. Although the polycrystal insulating material which makes AlN of this embedding layer a principal component was AlN in this example, in the case of the III-V group of the usual conventional material system used for semiconductor laser, the laser itself and the thing of large composition of the band gap of the same crystal material system were used as an insulating material for embedding layer 21 of the above. Since the refractive index became small, large composition of a band-gap value also produced the effective-refractive-index step by this, and was also able to perform eye *****.

[0012] Moreover, since perfect grid matching was conventionally acquired between the embedding layer 21 and laser structure in the case of the material system, the epitaxial re-growth without the continuous crystal defect was possible. In the case of the conventional nitride semiconductor laser, the material composition which should be used for the embedding layer 21 is $\text{Al}_x\text{Ga}_{1-x}\text{N}$, to proportion y of $\text{Al}_y\text{Ga}_{1-y}\text{N}$ of the clad layer in which this proportion x constitutes laser structure, unless it is $x > y$, a desirable light closes and eye ** is not obtained. Generally, in $\text{Al}_z\text{Ga}_{1-z}\text{N}$, unlike AlGaAs system, a lattice constant becomes small with the increase in proportion z. Therefore, a tensile stress strong against the embedding layer 21 will occur.

Consequently, a crack will occur at the time of re-growth of the embedding layer 21, and a crack will be spread also for the ridge stripe 15. A crack occurs because it is made to form by the epitaxial growth grids connected and grow up to be.

[0013] Although what is necessary will be just to form the conventional embedding layer 21 by SiO_2 (glassy) etc., there are three problems in this case. Heat conduction bad (0.014 W/cmK) very much, and SiO_2 checks [1st] thermolysis of semiconductor laser. The coefficient of thermal expansion of SiO_2 gives [2nd] distortion extremely to the semiconductor laser element itself by the parvus's ($5 \times 10^{-7} \text{ deg}^{-1}$). The expansion coefficient of GaN is 5.6×10^{-6} . It is because it is deg^{-1} . Therefore, SiO_2 thickness cannot be thickened but the flattening is difficult. a refractive-index difference is too large and the refractive index of SiO_2 tends to become [3rd] too (about 1.46) small a high order (width -- high order) mode oscillation.

[0014] Then, at the semiconductor laser of this invention, it is going to perform this embedding by the polycrystal insulating material which makes AlNs, such as AlN of a polycrystal, a principal component. Since the embedding layer 21 is polycrystal, the crack by the difference of a lattice constant does not occur between AlGaIn fractions

which are laser structure. The physical-properties value of an embedding layer material is shown in Table 1.

[0015]

[Table 1]

Thermal conductivity A coefficient of thermal expansion Refractive index AlN (single crystal) 2.85 W/cmK 2.15 AlN (polycrystal) 1.7 W/cmK 4.3×10^{-6} deg-1 SiO₂ 0.014 W/cmK 5×10^{-7} deg-1 1.46 GaN (single crystal) 1.3 W/cmK 5.6×10^{-6} Since deg-1 2.8 and AlN are usually insulators, the embedding layer 21 does not transmit a current at all. Therefore, it is hard to produce the problem of the parasitic capacitance produced when it embeds by the n-type semiconductor like before.

[0016] As mentioned above, since the advantage of this invention which used AlN for the embedding layer 21 is good, its thermal conductivity is advantageous to thermolysis, and it is more moderate than a low refractive index and SiO₂ from GaN at the high refractive index. [of thermal conductivity] Moreover, occurrence of asymmetry according [a coefficient of thermal expansion] to quite near and heat is suppressed by GaN of laser structure. Since AlN is a nearly perfect insulator, it does not have the leak of a current and does not have the parasitic-capacitance occurrence based on excessive pn junction. Furthermore, the advantage of this invention does not have occurrence of the crack resulting from grid mismatching, in order to form the embedding layer 21 in the shape of polycrystal by the spatter technique etc. In case of the embedding process, the high equipment of a running cost like CVD kiln is unnecessary.

[0017] Below, the example of the technique of producing the semiconductor laser of GaN system is explained from drawing 2 to up to the silicon on sapphire by this invention based on drawing 10. As shown in drawing 2, the wafer of silicon on sapphire 1 is prepared and clarification of the front face is carried out by the organic solvent etc. on it first, by the predetermined epitaxial growth technique, the organic-metal vapor growth, the molecular-beam grown method, etc. The current path layer 2 of n type GaN, the clad layer 3 of n type AlGaIn, the guide layer 4 of n type GaN, the barrier layer 5 of InGaIn, the guide layer 6 of p type GaN, the clad layer 7 of p type AlGaIn, and the contact layer 8 of p type GaN are ****ed in this order, and a laser substrate wafer is produced. Moreover, in growth of the guide layer 6, the clad layer 7, and the contact layer 8, Mg is doped that it should consider as p type. In addition, you may prepare AlN buffer layer (not shown) between silicon on sapphire 1 and the current path layer 2 of n type GaN.

[0018] Next, since the layer which carried out Mg dope is insulation if it remains as it is, it heat-treats a substrate wafer in N₂ gas, and forms the guide layer 6, the clad layer 7, and the contact layer 8 into p mold. Next, nickel is made to -ed ** by resistance heating vacuum evaporation all over contact layer of wafer 8. Next, as shown in drawing 3, patterning of the nickel layer 9 is carried out using the usual process by the photoresist and wet etching.

[0019] Next, as shown in drawing 4, reactive ion etching (RIE) using Cl₂ gas performs dry etching, using the nickel layer 9 as a mask, it removes to the clad layer 3 of n type AlGaIn, and the current path layer 2 of n type GaN is exposed. Next, a photoresist layer is applied, and by wet etching, as shown in drawing 5, the pattern of the photoresists 17a and 17b for formation of the fraction which should serve as a ridge stripe, p lateral-electrode section, and n lateral-electrode section is made.

Especially photoresist 17a leaves predetermined width of face for the nickel layer 9, and it is used in order to form the 2nd electrode 40 of the shape of a stripe of nickel layer.

[0020] Next, as shown in drawing 6, the 2nd electrode 40 of photoresist 17a and nickel is used as a mask, by the dry etching of RIE using Cl₂ gas, the etching of a part of contact layer 8 of p type GaN and clad layer 7 of p type AlGaIn is carried out, and the stripe 15 of the ridge section is formed. At this time, etching is stopped in the middle of the clad layer 7 of p type AlGaIn.

[0021] Next, as shown in drawing 7, it forms so that a polycrystal AlN layer may be made to deposit to the level of the top of the 2nd electrode 40, that is, the embedding layer 21 and the 2nd electrode 40 of the ridge stripe 15 may become the same height by the reactive sputtering system using aluminum target, N₂ gas, and Ar gas. Next, as shown in drawing 8, elimination liquid removes photoresists 17a and 17b, this removes AlN layer which suited on each resist pattern by the lift off, and the 2nd electrode 40 of nickel and a part of current path layer 2 of n type GaN are exposed.

[0022] next -- the nickel 2nd electrode 40 top exposed as shown in drawing 9 -- for the n lateral electrode 31, vacuum deposition of the electrode material is carried out to the order of Ti and Au on the current path layer 2 of n type GaN in the order of Cr and Au for the p lateral electrode 30, and electrode formation is carried out, respectively Then, semiconductor laser is completed by the predetermined process.

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TECHNICAL FIELD

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PRIOR ART

[Prior art] Semiconductor laser is known as an element which it is used for the light source of optical-pickup equipment of in read-out / optical information record regenerative apparatus to write in for a signal from an optical disk, and also may be applied to optical transmission systems, such as optical CATV, the pump light source of high-density information record SHG short wavelength laser or small solid state laser, an optical instrumentation field, etc. In order to operate by the small current and to perform a longitudinal direction single-mode oscillation, it is necessary to confine the electron, the electron hole, and oscillation light in a semiconductor in a parvus field. In the pn junction perpendicular direction, it has shut up by double hetero structure etc. Although there is gain **** structure as technique of restricting the photogenesis field of laser, about orientation parallel to a junction, in order that a wave front may generally be distorted and astigmatism may come out of this, for the intended use of the light source for disk read, the semiconductor laser of refractive-index **** structure is used. Refractive-index **** structure is the structure where carry out forming not only a junction perpendicular direction but a ridge stripe etc., and a junction parallel direction also faces across a photogenesis field at the charge of a clad plate with a low refractive index.

[0003] Since the effective refractive index to the light which spreads the guide layer of the ridge lower part will become large a little from the other fraction if a part of clad layers other than the fraction of a current injection field are removed by etching etc. and a ridge stripe is formed, light is shut up by the ridge lower fraction. An electrode is prepared in the ridge upper part, and a current is poured in and it is made to oscillate between an electrode and a substrate in ridge type semiconductor laser.

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TECHNICAL PROBLEM

[Object of the Invention] On the other hand, occurrence of heat becomes a problem when using semiconductor laser by continuous oscillation. Then, in order to improve thermolysis, mounting of the so-called junction down the electrode of the ridge upper part is contacted [the down] to a heat sink is performed. Since the width of face of the projected ridge fraction is several [only] micrometers when it is going to perform this installation technique, there is a problem by which an element will be destroyed in this ** with a heat sink.

[0005] Then, the need of carrying out the flattening of the side from which the ridge stripe fraction of laser is made arises. It embeds to the almost same height as a ridge stripe fraction, and considers forming and carrying out the flattening of the layer. However, in SiO₂, along with the side attachment wall of the ridge section, it had to form thinly, the flattening was difficult, and selection of an embedding material was difficult. [0006] Then, it aims at offering the ridge type semiconductor laser which has a ridge stripe on the laser structure layer which can be equal to junction down mounting, and its manufacture technique in this invention.

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MEANS

[The means for solving a technical problem] The process which this invention is the manufacture technique of the ridge type semiconductor laser which has a ridge stripe on a laser structure layer, and forms the laser substrate which carried out the laminating of the clad layer and the required contact layer of a ridge stripe material to order on a laser structure layer, The process which forms the stripe electrode of a ridge stripe pattern on the aforementioned clad layer and a required contact layer that the ridge stripe which projects from a both-sides flat part and these, and has the flat top section should be formed, The process which carries out the etching of the parts for a clad layer other than the clad layer covered by the aforementioned stripe electrode, and forms a ridge stripe and a both-sides flat part, The process which forms the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe, It is characterized by including the process which removes the layer on the aforementioned stripe electrode, is made to expose the aforementioned stripe electrode, and forms the flat top section, and the process which forms an electrode on the aforementioned flat top section.

[0008] In the manufacture technique of the semiconductor laser of this invention, it is characterized by being the multilayer to which the aforementioned laser structure layer makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})\text{-yIn}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$). In the manufacture technique of the semiconductor laser of this invention, it is characterized by the aforementioned embedding stratification process including a spatter process.

[0009] The semiconductor laser of this invention is characterized by having the embedding layer which deposits the polycrystal insulating material which makes a principal component AlN which has a refractive index lower than the refractive index of ridge type semiconductor laser ***** which has a both-sides flat part and the ridge stripe which has the flat top section which is projected from these, and by which an electrode is formed on a laser structure layer, and a laser structure layer on the aforementioned both-sides flat part, and sandwiches the aforementioned ridge stripe.

[0010]

[Gestalt of implementation of invention] Hereafter, the example of this invention is explained, referring to a drawing. First, the ridge stripe embedding technique in the n type semiconductor layer in the ridge type semiconductor laser which has a ridge stripe is explained. Ridge type semiconductor laser is shown in drawing 1. This ridge

type semiconductor laser has the laser structure which consists of the clad layer 3 of n type AlGaIn, the guide layer 4 of n type GaN, the barrier layer 5 of InGaIn, a guide layer 6 of p type GaN, and a clad layer 7 of p type AlGaIn. A laser structure layer is a multilayer which makes a principal component $1(\text{Al}_x\text{Ga}_{1-x})_y\text{In}_y\text{N}$ ($0 \leq x \leq 1$, $0 \leq y \leq 1$). In order to form this laser structure layer on the silicon on sapphire 1 in which the current path layer 2 of n type GaN was formed and to shut up light, the ridge stripe 15 for which the clad layer 7 of p type AlGaIn projects from the both-sides flat part 14 into which it was etched, and these is formed on the laser structure layer. Moreover, the contact layer 8 of p type GaN, and the stripe-like 2nd electrode 40 are formed in the flat top section of the ridge stripe 15, and the p lateral electrode 30 is further formed on it.

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[0012] Moreover, since perfect grid matching was conventionally acquired between the embedding layer 21 and laser structure in the case of the material system, the epitaxial re-growth without the continuous crystal defect was possible. In the case of the conventional nitride semiconductor laser, the material composition which should be used for the embedding layer 21 is $\text{Al}_x\text{Ga}_{1-x}\text{N}$, to proportion y of $\text{Al}_y\text{Ga}_{1-y}\text{N}$ of the clad layer in which this proportion x constitutes laser structure, unless it is $x > y$, a desirable light closes and eye ** is not obtained. Generally, in $\text{Al}_z\text{Ga}_{1-z}\text{N}$, unlike AlGaAs system, a lattice constant becomes small with the increase in proportion z. Therefore, a tensile stress strong against the embedding layer 21 will occur.

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[0013] Although what is necessary will be just to form the conventional embedding layer 21 by SiO_2 (glassy) etc., there are three problems in this case. Heat conduction bad (0.014 W/cmK) very much, and SiO_2 checks [1st] thermolysis of semiconductor laser. The coefficient of thermal expansion of SiO_2 gives [2nd] distortion extremely to the semiconductor laser element itself by the parvus's ($5 \times 10^{-7} \text{ deg}^{-1}$). The expansion coefficient of GaN is 5.6×10^{-6} . It is because it is deg^{-1} . Therefore, SiO_2 thickness cannot be thickened but the flattening is difficult. a refractive-index difference is too large and the refractive index of SiO_2 tends to become [3rd] too (about 1.46) small a high order (width -- high order) mode oscillation

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[0015]

[Table 1]

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[0018] Next, since the layer which carried out Mg dope is insulation if it remains as it is, it heat-treats a substrate wafer in N₂ gas, and forms the guide layer 6, the clad layer 7, and the contact layer 8 into p mold. Next, nickel is made to -ed ** by resistance heating vacuum evaporation all over contact layer of wafer 8. Next, as shown in drawing 3, patterning of the nickel layer 9 is carried out using the usual process by the photoresist and wet etching.

[0019] Next, as shown in drawing 4, reactive ion etching (RIE) using Cl₂ gas performs dry etching, using the nickel layer 9 as a mask, it removes to the clad layer 3 of n type AlGaIn, and the current path layer 2 of n type GaN is exposed. Next, a photoresist layer is applied, and by wet etching, as shown in drawing 5, the pattern of the photoresists 17a and 17b for formation of the fraction which should serve as a

ridge stripe, p lateral-electrode section, and n lateral-electrode section is made. Especially photoresist 17a leaves predetermined width of face for the nickel layer 9, and it is used in order to form the 2nd electrode 40 of the shape of a stripe of nickel layer.

[0020] Next, as shown in drawing 6 , the 2nd electrode 40 of photoresist 17a and nickel is used as a mask, by the dry etching of RIE using Cl₂ gas, the etching of a part of contact layer 8 of p type GaN and clad layer 7 of p type AlGaIn is carried out, and the stripe 15 of the ridge section is formed. At this time, etching is stopped in the middle of the clad layer 7 of p type AlGaIn.

[0021] Next, as shown in drawing 7 , it forms so that a polycrystal AlN layer may be made to deposit to the level of the top of the 2nd electrode 40, that is, the embedding layer 21 and the 2nd electrode 40 of the ridge stripe 15 may become the same height by the reactive sputtering system using aluminum target, N₂ gas, and Ar gas. Next, as shown in drawing 8 , elimination liquid removes photoresists 17a and 17b, this removes AlN layer which suited on each resist pattern by the lift off, and the 2nd electrode 40 of nickel and a part of current path layer 2 of n type GaN are exposed.

[0022] next -- the nickel 2nd electrode 40 top exposed as shown in drawing 9 -- for the n lateral electrode 31, vacuum deposition of the electrode material is carried out to the order of Ti and Au on the current path layer 2 of n type GaN in the order of Cr and Au for the p lateral electrode 30, and electrode formation is carried out, respectively Then, semiconductor laser is completed by the predetermined process.

[Translation done.]

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DESCRIPTION OF DRAWINGS

[An easy explanation of a drawing]

[Drawing 1] It is the outline perspective diagram of semiconductor laser.

[Drawing 2] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 3] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 4] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 5] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 6] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 7] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 8] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[Drawing 9] It is the outline cross section of the laser substrate in the manufacturing process of the semiconductor laser of the example by this invention.

[An explanation of the sign of main fractions]

- 1 Silicon on Sapphire
- 2 Current Path Layer of N Type GaN
- 3 Clad Layer of N Type AlGaIn
- 4 Guide Layer of N Type GaN
- 5 Barrier Layer of InGaIn
- 6 Guide Layer of P Type GaN
- 7 Clad Layer of P Type AlGaIn
- 8 Contact Layer of P Type GaN
- 14 Both-Sides Flat Part
- 15 Ridge Stripe
- 15a Flat top section
- 17a, 17b Resist layer
- 21 Embedding Layer
- 30, 31 P lateral electrode
- 40 2nd Electrode

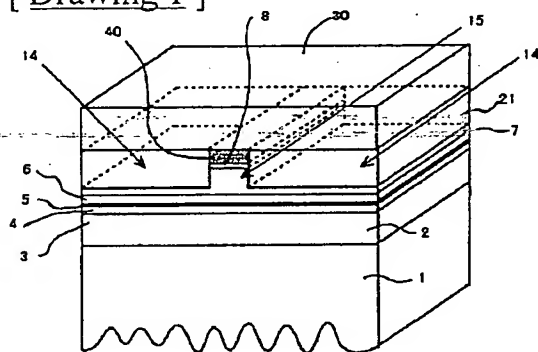
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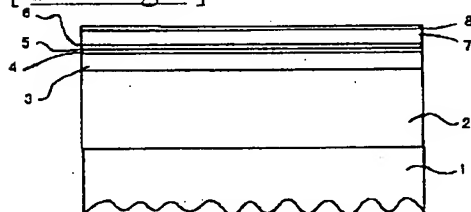
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DRAWINGS

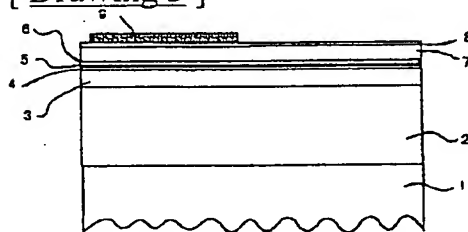
[Drawing 1]



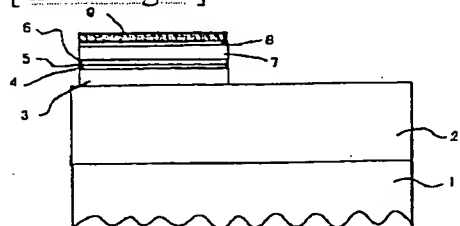
[Drawing 2]



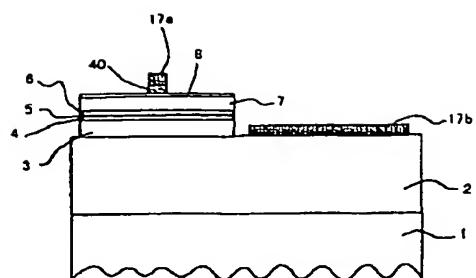
[Drawing 3]



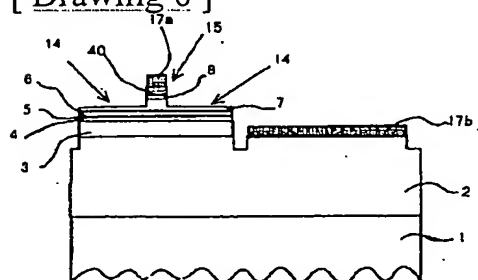
[Drawing 4]



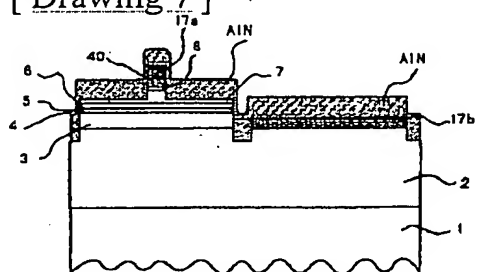
[Drawing 5]



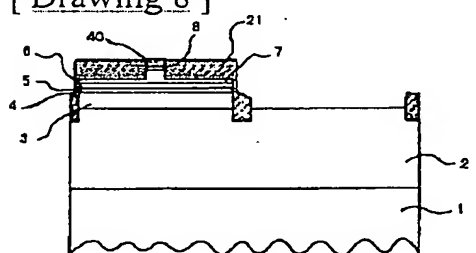
[Drawing 6]



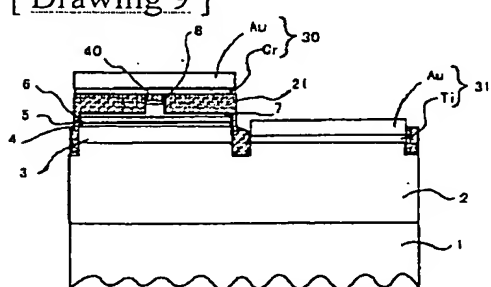
[Drawing 7]



[Drawing 8]



[Drawing 9]



[Translation done.]

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【特許請求の範囲】

【請求項1】 レーザ構造層上にリッジストライプを有するリッジ型半導体レーザの製造方法であって、レーザ構造層上にリッジストライプ材料のクラッド層及び必要なコンタクト層を順に積層したレーザ基板を形成する工程と、
 両側平坦部とこれらから突出し平坦上面部を有するリッジストライプとを形成すべく、リッジストライプパターンのストライプ電極を前記クラッド層及び必要なコンタクト層上に形成する工程と、
 前記ストライプ電極で覆われたクラッド層以外のクラッド層部分を食刻してリッジストライプ及び両側平坦部を形成する工程と、
 レーザ構造層の屈折率より低い屈折率を有するAINを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を形成する埋め込み層形成工程と、
 前記ストライプ電極上の層を除去し前記ストライプ電極を露出せしめ平坦上面部を形成する工程と、
 前記平坦上面部に電極を形成する工程と、を含むことを特徴とする半導体レーザ製造方法。

【請求項2】 前記レーザ構造層が(AI, Ga, ...) In, N ($0 \leq x \leq 1$, $0 \leq y \leq 1$)を主成分とする多層であることを特徴とする請求項1記載の半導体レーザ製造方法。

【請求項3】 前記埋め込み層形成工程はスパッタ工程を含むことを特徴とする請求項1又は2記載の半導体レーザ製造方法。

【請求項4】 レーザ構造層上に、両側平坦部と、これらから突出し電極が形成される平坦上面部を有するリッジストライプと、を有するリッジ型半導体レーザであって、
 レーザ構造層の屈折率より低い屈折率を有するAINを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を有することを特徴とする半導体レーザ。

【請求項5】 前記レーザ構造層が(AI, Ga, ...) In, N ($0 \leq x \leq 1$, $0 \leq y \leq 1$)を主成分とする多層であることを特徴とする請求項4記載の半導体レーザ。

【請求項6】 前記AINを主成分とする多結晶絶縁材料はAINであることを特徴とする請求項4又は5記載の半導体レーザ。

【発明の詳細な説明】

【0001】
 【発明の属する技術分野】 本発明は、半導体レーザ及びその製造方法に関する。

【0002】
 【従来の技術】 半導体レーザは、光ディスクから信号を読み出し／書き込む光学式情報記録再生装置における光ビ

ックアップ装置の光源に用いられる他に、光CATVなどの光通信システムや、高密度情報記録SHG短波長レーザ、又は小型固体レーザのポンプ光源や、光計測分野などに応用され得る素子として知られている。小電流で動作し偏方向単一モード発振を行うためには半導体中の電子及び正孔並びに発振光を小さい領域に閉じこめる必要がある。pn接合垂直方向ではダブルヘテロ構造などで閉じこめている。接合に平行な方向に関して、レーザの発光領域を制限する方法として利得導波構造があるが、これは一般に波面がゆがみ、非点収差が出てしまうため、ディスク読取り用光源の用途などでは、屈折率導波構造の半導体レーザが使われる。屈折率導波構造は、接合垂直方向だけでなく、リッジストライプを形成するなどして接合平行方向でも屈折率の低いクラッド材料で発光領域を挟む構造である。

【0003】電流注入領域の部分以外のクラッド層の一部をエッチングなどで除去し、リッジストライプを形成するとリッジ下部のガイド層を伝搬する光に対する実効屈折率が、それ以外の部分より、若干大きくなるため、リッジ下部部分に光が閉じ込められる。リッジ型半導体レーザでは、リッジ上部に電極を設け、電極及び基板間に電流を注入して発振させる。

【0004】

【発明が解決しようとする課題】 一方、半導体レーザを連続発振で使用する場合には問題になるのが、熱の発生である。そこで放熱を良くするため、リッジ上部の電極をヒートシンクに接触させる。いわゆるジャンクションダウンのマウントが行なわれる。この設置方法を行なおうとすると、突出しているリッジ部分の幅がわずかな数 μm のため、ヒートシンクとの当接にて素子が破壊されてしまう問題がある。

【0005】そこで、レーザのリッジストライプ部分が作られている側を平坦化する必要が生ずる。リッジストライプ部分とはほぼ同じ高さまで埋め込み層を形成して平坦化することが考えられている。しかし、SiO₂などではリッジ部の側壁に沿って薄く形成しなければならず平坦化が困難で、埋め込み材料の選択が難しいものであった。

【0006】そこで、本発明では、ジャンクションダウンマウントに耐え得るレーザ構造層上にリッジストライプを有するリッジ型半導体レーザ及びその製造方法を提供することを目的とする。

【0007】

【課題を解決するための手段】 本発明は、レーザ構造層上にリッジストライプを有するリッジ型半導体レーザの製造方法であって、レーザ構造層上にリッジストライプ材料のクラッド層及び必要なコンタクト層を順に積層したレーザ基板を形成する工程と、両側平坦部とこれらから突出し平坦上面部を有するリッジストライプとを形成すべく、リッジストライプパターンのストライプ電極を

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前記クラッド層及び必要なコンタクト層上に形成する工程と、前記ストライプ電極で覆われたクラッド層以外のクラッド層部分を食刻してリッジストライプ及び両側平坦部を形成する工程と、レーザ構造層の屈折率より低い屈折率を有するA1Nを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を形成する工程と、前記ストライプ電極上の層を除去し前記ストライプ電極を露出せしめ平坦上面部を形成する工程と、前記平坦上面部上に電極を形成する工程と、を含むことを特徴とする。

【0008】本発明の半導体レーザの製造方法においては、前記レーザ構造層が(A1,Ga...),...In,N ($0 \leq x \leq 1$, $0 \leq y \leq 1$)を主成分とする多層であることを特徴とする。本発明の半導体レーザの製造方法においては、前記埋め込み層形成工程はスパッタ工程を含むことを特徴とする。

【0009】本発明の半導体レーザは、レーザ構造層上に、両側平坦部と、これらから突出し電極が形成される平坦上面部を有するリッジストライプと、を有するリッジ型半導体レーザであって、レーザ構造層の屈折率より低い屈折率を有するA1Nを主成分とする多結晶絶縁材料を前記両側平坦部上に堆積して前記リッジストライプを挟む埋め込み層を有することを特徴とする。

【0010】

【発明の実施の形態】以下、本発明の実施例を図面を参照しつつ説明する。まず、リッジストライプを有するリッジ型半導体レーザにおける、n型の半導体層でのリッジストライプ埋め込み方法を説明する。図1にリッジ型半導体レーザを示す。このリッジ型半導体レーザは、n型AlGaInのクラッド層3、n型GaInのガイド層4、InGaInの活性層5、p型GaInのガイド層6及びp型AlGaInのクラッド層7からなるレーザ構造を有している。レーザ構造層は(A1,Ga...),...In,N ($0 \leq x \leq 1$, $0 \leq y \leq 1$)を主成分とする多層である。このレーザ構造層はn型GaInの電流経路層2が形成されたサファイア基板1上に形成され、光を閉じこめるために、p型AlGaInのクラッド層7がエッチングされた両側平坦部14とこれらから突出するリッジストライプ15とがレーザ構造層上に形成されている。また、リッジストライプ15の平坦上面部にはp型GaInのコンタクト層8及びストライプ状の第2電極40が形成され、さらにその上にp側電極30が形成されている。

【0011】このリッジ型半導体レーザは、レーザ構造層の屈折率より低い屈折率を有するA1Nを主成分とする*

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* 多結晶絶縁材料を両側平坦部14上に堆積したリッジストライプ15を挟む埋め込み層21を有している。本実施例では、この埋め込み層のA1Nを主成分とする多結晶絶縁材料はA1Nであるが、半導体レーザに用いられる通常の従来材料系のIII-V族の場合、上記の埋め込み層21用の絶縁材料として、レーザそのものと同様な結晶材料系のバンドギャップの大きい組成のものを用いていた。バンドギャップ値の大きい組成は屈折率が小さくなるので、これにより実効屈折率ステップも生じて、光閉じ込めも行なえた。

【0012】また、従来材料系の場合、埋め込み層21と、レーザ構造との間で完全な格子整合を得ることができたので、連続した結晶欠陥のないエピタキシャル再成長が可能であった。従来の窒化物半導体レーザの場合、埋め込み層21に用いるべき材料組成はA1,Ga...Nで、この比率xはレーザ構造を成すクラッド層のA1,Ga...Nの比率yに対し、 $x > y$ でない限り、望ましい光の閉じ込めが得られない。一般に、A1,Ga...Nの場合、AlGaAs系とは異なり、比率zの増加と共に格子定数が小さくなる。従って、埋め込み層21には強い引っ張り応力が発生してしまう。この結果、埋め込み層21の再成長時にクラックが発生してしまい、クラックはリッジストライプ15にも伝播してしまうことになる。クラックが発生するのは、格子同士がつながって成長するエピタキシャル成長で形成させるからである。

【0013】従来の埋め込み層21を例えばSiO₂（ガラス質）などで形成すれば良いことになるが、この場合、3つの問題がある。第1に、SiO₂は熱伝導が極めて悪い（0.014 W/cmK）ので、半導体レーザの放熱を阻害する。第2に、SiO₂の熱膨張係数が極めて小さい（ 5×10^{-6} deg⁻¹）ので、半導体レーザ素子自体に歪を与える。GaInの膨張係数は 5.6×10^{-6} deg⁻¹であるからである。よって、SiO₂膜厚を厚くできず平坦化が困難である。第3に、SiO₂の屈折率が小さすぎる（1.46程度）ので、屈折率差が大きすぎて、高次（構高次）モード発振になり易い。

【0014】そこで、本発明の半導体レーザでは、多結晶のA1NなどのA1Nを主成分とする多結晶絶縁材料でこの埋め込みを行なおうとするものである。埋め込み層21が多結晶なので、レーザ構造であるAlGaIn部分との間で格子定数の差によるクラックが発生しない。埋め込み層材料の物性値を表1に示す。

【0015】

【表1】

	熱伝導率	熱膨張係数	屈折率
A1N (単結晶)	2.55 W/cmK	-	2.15
A1N (多結晶)	1.7 W/cmK	4.3×10^{-6} deg ⁻¹	-
SiO ₂	0.014 W/cmK	5×10^{-6} deg ⁻¹	1.46
GaIn (単結晶)	1.3 W/cmK	5.6×10^{-6} deg ⁻¹	2.8

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また、AINは、通常、絶縁体であるので、埋め込み層21はまったく電流を通さない。したがって、従来のようにn型半導体で埋め込んだ場合に生ずる寄生容量の問題も生じにくい。

【0016】以上、埋め込み層21にAINを用いた本発明の利点は、熱伝導率が良いので、放熱に有利であり、Ga_{0.5}Nより低屈折率かつSiO₂より高屈折率で適度である。また、熱膨張係数がレーザ構造のGa_{0.5}Nにかなり近く、熱による歪みの発生が抑制される。AINはほぼ完全な絶縁体なので、電流の流れが全くなく、余分なpn接合に基づく寄生容量発生がない。さらに、本発明の利点は、埋め込み層21をスパッタ方法などで多結晶状に形成するため、格子不整合に起因するクラックの発生がない。埋め込み工程に際し、CVD炉のようなランニングコストの高い装置が不要である。

【0017】以下に、本発明によるサファイア基板上へGa_{0.5}N系の半導体レーザを作製する方法の実施例を図2から図10に基づいて説明する。まず、図2に示すように、サファイア基板1のウェハを用意し、有機溶媒などで表面を清浄し、その上に、所定のエピタキシャル成長方法、有機金属気相成長法、分子線成長法などで、n型Ga_{0.5}Nの電流経路層2、n型AlGa_{0.5}Nのクラッド層3、n型Ga_{0.5}Nのガイド層4、InGa_{0.5}Nの活性層5、p型Ga_{0.5}Nのガイド層6、p型AlGa_{0.5}Nのクラッド層7、及びp型Ga_{0.5}Nのコンタクト層8を、この順で成膜し、レーザ基板ウェハを作製する。また、ガイド層6、クラッド層7及びコンタクト層8の成長ではp型とすべくMgのドーピングを行っている。なお、サファイア基板1及びn型Ga_{0.5}Nの電流経路層2の間にAINバッファ層（図示せず）を設けてもよい。

【0018】次に、Mgドーピングした膜はそのままでは絶縁性なので、基板ウェハを、N₂ガス中で熱処理して、ガイド層6、クラッド層7及びコンタクト層8をp型化する。次に、ウェハのコンタクト層8全面に抵抗加熱蒸着でNiを被着させる。次に、図3に示すように、フォトリソストとウェットエッチングによる通常のプロセスを用いて、Ni膜9をパターニングする。

【0019】次に、図4に示すように、Ni膜9をマスクとして、Cl₂ガスを用いた反応性イオンエッチング（RIE）によりドライエッチングを行なって、n型AlGa_{0.5}Nのクラッド層3まで除去してn型Ga_{0.5}Nの電流経路層2を露出させる。次に、フォトリソスト膜を塗布して、ウェットエッチングにより、図5に示すように、リッジストライプ及びp側電極部並びにn側電極部となるべき部分の形成用のフォトリソスト17a、17bのパターンを作る。特に、フォトリソスト17aはNi膜9を所定幅を残して、Ni膜のストライプ状の第2電極40を形成するために用いられる。

【0020】次に、図6に示すように、フォトリソスト17a及びNiの第2電極40をマスクとしてCl₂ガ

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スを用いたRIEのドライエッチングにより、p型Ga_{0.5}Nのコンタクト層8及びp型AlGa_{0.5}Nのクラッド層7の一部を食刻して、リッジ部のストライプ15を形成する。この時、p型AlGa_{0.5}Nのクラッド層7の途中でエッチングを停止する。

【0021】次に、図7に示すように、反応性スパッタリング装置により、Alターゲット並びにN₂ガス及びArガスを用いて、多結晶AIN膜を、第2電極40の上面のレベルまで堆積させ、つまり埋め込み層21とリッジストライプ15の第2電極40とが同じ高さになるように形成する。次に、図8に示すように、フォトリソスト17a、17bを除去液で除去し、これにより、各レジストパターン上にあったAIN膜をリフトオフで除去し、Niの第2電極40及びn型Ga_{0.5}Nの電流経路層2の一部を露出させる。

【0022】次に、図9に示すように、露出したNiの第2電極40上にはp側電極30のためにCr、Auの順で、n側電極31のためには、Ti、Auの順に電極材をn型Ga_{0.5}Nの電流経路層2上に真空蒸着して、それぞれ電極形成する。その後、所定工程により、半導体レーザが完成される。

【図面の簡単な説明】

【図1】半導体レーザの概略斜視図である。

【図2】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図3】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図4】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図5】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図6】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図7】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図8】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【図9】本発明による実施例の半導体レーザの製造工程中におけるレーザ基板の概略断面図である。

【主要部分の符号の説明】

- 1 サファイア基板
- 2 n型Ga_{0.5}Nの電流経路層
- 3 n型AlGa_{0.5}Nのクラッド層
- 4 n型Ga_{0.5}Nのガイド層
- 5 InGa_{0.5}Nの活性層
- 6 p型Ga_{0.5}Nのガイド層
- 7 p型AlGa_{0.5}Nのクラッド層
- 8 p型Ga_{0.5}Nのコンタクト層
- 14 両側平坦部
- 15 リッジストライプ

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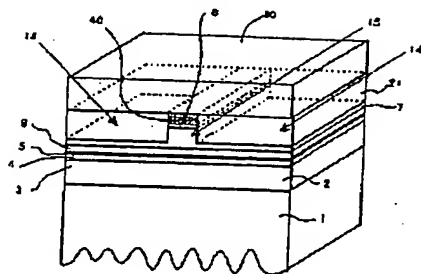
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15a 平坦上面部
17a、17b レジスト層
21 埋め込み層

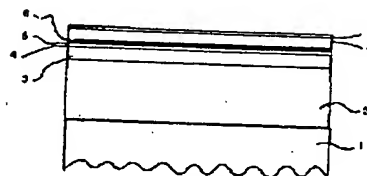
* 30. 31 P側電極
40 第2電極

*

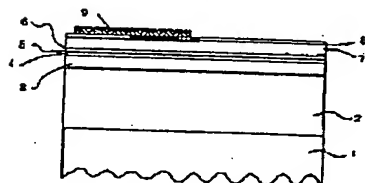
【圖 1】



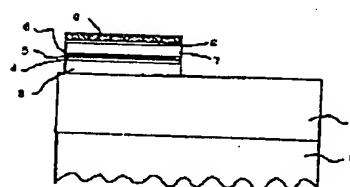
【圖2】



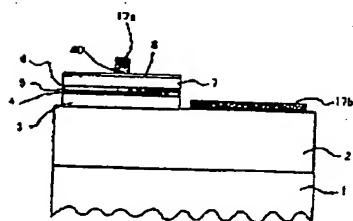
【圖3】



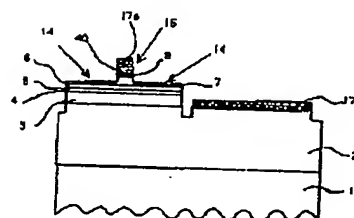
【圖4】



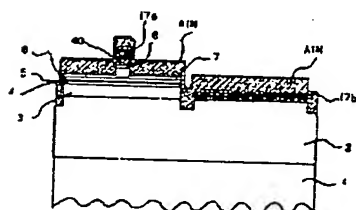
【圖5】



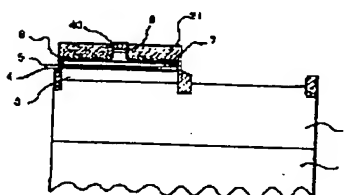
【圖6】



【圖 7】



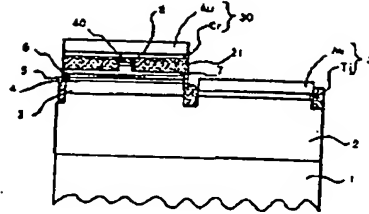
【圖8】



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【図9】



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